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SURGERY

OF THE

ARTERIES;

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There can be little difference of opinion as to the broad distinction that theoretically separates the pathological results of arterial disease and wounds of arteries. In the one, a tumor due to arterial expansion results; in the other, a swelling caused by extravasation of blood is to be seen. In the former a sac, produced by the distended vascular tunics and compressed adjacent tissues, restrains the circulating fluid and keeps it within bounds; in the latter no sac is to be found, and the extravasated blood separates contiguous organs, dissects out important structures, and is only checked when neighboring parts are compressed by unyielding fascial envelopes. In the one case we have an enlarged blood vessel; in the other, a wounded or ruptured artery. The treatment that should be adopted in these different cases has been obscured by the name given them. By calling such widely unlike morbid anatomical states as an enlarged vascular trunk, due to arterial disease, and an extravasation of blood, caused by a ruptured or wounded artery, by the same term, "aneurism," an unnecessary and very distressing complication has arisen. Students are compelled to associate the therapeutical procedures necessary for the cure of an aneurism with the cause of the individual tumor, instead of connecting the pathological lesion present in a given case with the restorative provisions of Nature. Observation teaches that Nature resorts to one or more of a restricted series of phenomena in her efforts to cure a tumor resulting from a distended artery; the deposition of layer after layer of fibrin in the aneurismal sac may obliterate the tumor; these layers may be so placed that the cavity is filled without obstructing the canal of the blood-vessel; a part of one of these layers may be so displaced as to close the out-

let of the sac, the blood within the latter at once coagulating; or, finally, inflammation and suppuration may completely destroy the tumor. The first three of these four processes may cure; the last one is almost certain to kill. The great treasures of surgery have been unearthed by careful study and diligent imitation of Nature's processes. Thus, it has been discovered that these beneficial procedures of Nature differ in merit in the part of the body in which the aneurism is located, and can be accelerated or retarded by certain steps on the part of the surgeon. To aid in effecting a cure it is not necessary that the blood be stopped passing through the sac, although it is essential that the force of the circulation be diminished and the rapidity of the flow through the tumor reduced.

It is unnecessary for me to review the different measures surgeons have resorted to for the purpose of reducing the rapidity and force of the circulation; rest, position, pressure, compression, electro-puncture, the "old operation," manipulation and ligation, or torsion, are among the more important. In all these, in order that a cure may be effected, it is necessary that a sac be in existence in which the blood may coagulate; or upon the walls of which layers of fibrin may be deposited, and that in those instances in which the main artery is occluded, a collateral circulation be established. Many cases can now be cured by the milder agencies, reserving for those that resist the more radical procedures—ligation, torsion, or the "old operation." Surgical history has no brighter page than that which records the contributions of Anel, Hunter, Brasdor, Wardrop and Syme to the surgery of arteries. Anel ligated on the cardiac side of the tumor, near the sac; Hunter tied higher up, where the artery was healthy; Brasdor went to the distal side of the tumor, ligating near the aneurism; Wardrop tied on the same side as Brasdor, but placed his ligature nearer the periphery. Of these procedures Anel's has no advantage not shared by Hunter's while Hunter's possesses merits to which Anel's is a stranger. On the other hand, the Hunterian operation is free from dangers that beset the method of Anel. The distal operations—although both operations of necessity—differ as decidedly as the foregoing. The operation of Wardrop, however, has a bright outlook, and the surgical authorities of the day are among its earnest advocates. To Syme we are indebted for a revival of the "old operation"—a procedure imitating the fourth and last method Nature occasionally adopts for the cure of

aneurism. Inflammation and suppuration may destroy an aneurismal tumor—unfortunately at the same time killing the patient by hemorrhage. Syme opened boldly certain aneurisms, turned out the clots, and tied the artery just at, but above and below the tumor. His success emboldened him to urge this method as one free from the great mortality of the Hunterian operation, and therefore especially valuable in iliac, axillary, gluteal and femoral aneurisms.

Before glancing at the state of a ruptured or a wounded artery, and reviewing the phenomena that assimilate it to or distinguish it from an aneurism, it may be of interest to look at the changes which ensue when a ligature is placed upon one of the great arterial trunks. Essentially the same phenomena noted after severing the sympathetic nerve in the neck are to be seen; the dilatation of minute vessels and the speedy development of a collateral circulation are the features of greatest interest to the practical surgeon. Whether this result is brought about by destroying the vasomotor nerve supply, or not, is a minor question; it is a fact of observation that for some reason or other these vessels do open when the main trunk is ligated, and that in this way the all-important collateral circulation is established.

The principal surgical measure for the cure of aneurism is ligation or torsion. The great danger overshadowing all cases of ligation is secondary hemorrhage. Experience shows that the ligature itself contributes materially to this unfortunate result. Although the greater part of the wound may unite by first intention, still the ligature, that during the operation was soaked in blood, and for the forty-eight hours following, was impregnated with wound secretions, ultimately occupies a funnel-like opening through which pus is drained—an opening communicating with the air at one end and reaching to the compressed artery at the other. The result is that decomposition commences at the surface, passes down the ligature, and finally surrounds the ligated vessel with a ring of putrescent material. Again, the ligature, where it compresses the artery—especially if the middle and internal coats are severed and retracted—destroys a certain portion of the external coat and necessitates a process of ulceration that in the end casts off this slough. There is, furthermore, in connection with these phenomena an interruption of nutrition not limited to the part directly grasped by the loop of the ligature, which exerts a material influence upon the reparative processes which seal

the central and distal extremities of the artery. It is a fact of far-reaching significance, that the reparative process, which seals the distal end of a ligated artery, is much less perfect than that which closes the cardiac extremity. Whether this be due to disturbance of the nerve supply of the part, or that the blood in contact with the distal end has passed through the avenues making up the collateral circulation, and no longer possesses the peculiar tint and character of arterial blood, I am unable to say. Be the explanation what it may, the fact that the distal end of a ligated artery is less perfectly sealed than the cardiac extremity cannot be denied. When this fact is borne in mind, it will surprise no one to learn that secondary hemorrhage far more frequently comes from the distal end of a ligated artery than from its cardiac extremity, although all our preconceptions—such as arise from our knowledge of nearness to the circulatory center, the force of the heart and the degree of arterial pressure—prepare us for just the opposite statement.

A knife is forced into the body and an artery wounded; the arterial injury is slight, yet the secondary changes, congestion, infiltration and softening of the walls of the vessel, ultimately cause the latter to yield. A more decided injury is inflicted; arterial blood flows for a time, hemorrhage ceases and the wound in the skin heals. In both these cases a pulsating tumor may soon form, revealing the fact that a so-called "false aneurism" has developed at the point where the artery was wounded. Contusions may injure or strains rupture an artery. In fractures a spicula may puncture, in necrosis a fragment erode an important vessel. In gun-shot injuries an artery may be wounded, or in attempts at reducing dislocations a vessel may be torn. A "false aneurism" may follow any one of these lesions. Should it not invariably be denominated what it is—a wounded or ruptured artery, and no longer called what it is not—an aneurism? The last reason I shall adduce in favor of this change of name, or rather, this return to the proper name, is that the treatment indicated in the one is contra-indicated in the other; the measures that cure aneurism are not those that should be adopted for the cure of wounds or ruptures of arteries.

Eliminating rest, position, pressure, compression, electro-puncture and manipulation, as agencies applicable to but few of the cases of true aneurism, we find that torsion or ligation, in some form or other, is the great remedy. As before stated, the Hunterian operation is the surgeon's choice; the distal operation may be a matter of necessity

The presence of a sac, in which the blood may be made to coagulate, or upon the walls of which layer after layer of fibrin can be deposited, is fully as essential to the cure of the patient as the temporary cessation of the circulation, or the ultimate establishment of a collateral blood-supply. How is it with a wounded or ruptured artery? Here the skin may be perforated and the artery punctured —hemorrhage at once ensuing. The steps to be taken by the surgeon are materially modified by the presence or absence of hemorrhage—the same lesion may require very different treatment before and after the flow of blood is checked. Again, a piece of necrosed bone may puncture an artery and cause extravasation of blood without a wound of the integument. The same condition occasionally results from strains rupturing arterial trunks, or fractured bones puncturing them.

If a wounded artery bleeds and can be easily ligated, it should invariably be tied or twisted. Slight hemorrhage from a deep artery should be treated by graduated compression over the wound—severe hemorrhage resisting pressure, by torsion or ligation above and below the bleeding point. So far there can be no doubt as to the rule that should guide the surgeon; but what course shall he pursue when blood has been extravasated and is constantly accumulating in the tissues? Or, what do when the tissues are filled with clots, although apparently no more blood is flowing?

There can be no difference of opinion as to the principle that should guide the operator in many cases. He may be forced to forego ligating both ends of a bleeding artery when the finding of these structures necessitates great violence to important organs. Thus, after rest, position, pressure, etc., fail to check hemorrhage from a wound in the hand or foot, the brachial or femoral artery is tied or twisted, and graduated pressure applied. We now find the altered circumstances under which the latter operates sufficient to effect a cure. It is however, in those cases where

First, a pulsating tumor forms about a ruptured vessel, or after the wound that injures the artery has healed upon the surface; *Second*, where blood has accumulated and still accumulates in the tissues about a wounded artery, external hemorrhage having ceased; *Third*, where an enormous amount of blood distends to the utmost the parts about a ruptured or punctured artery—that authorities are not in unison as to the best course to be pursued, and where a rule should be formulated for the guidance of the operator.

If rest, position, local pressure, and uniform compression do not cure the first; if the same measures fail to check the advance of the second and cause its gradual diminution in size; and if the third resists like treatment, the next step, I hold, should be the same in each. The surgeon should temporarily control the flow of blood through the part, cut open the swelling, turn out the clots, and if blood comes from the wounded artery—and in most cases, even if it does not—at once twist or tie the vessel above and below the point of wound or rupture. Contrast this method with the Hunterian operation; in the latter the collateral circulation has been partially formed during the slow growth of the aneurismal tumor, consequently the main vessel can be occluded with but little danger of gangrene; the sac of the aneurism is filled with clotted blood, the result of rapid coagulation of its contents, or its walls are strengthened by the deposition of layer after layer of fibrin; in either case the arterial pressure is no longer able to dilate the walls of the tumor and the sac speedily contracts. In wounded or ruptured arteries, the surgeon can never be sure, prior to an operation, that the bleeding may not come from a small branch instead of the main vessel; in the former case, closing the principal artery of the extremity would require the development of the collateral circulation in a part not prepared for such a step, thus incurring great risk of gangrene; in the latter it would obliterate the main vessel in two places and leave but little hope of saving the limb. By opening the swelling, or dilating the wound, not only is the true source of the hemorrhage reached and its flow checked, but the accumulated clots are removed and the compressed tissues relieved, while all danger of inflammation, suppuration or gangrene is obviated.

There are two forms of arterial lesion in which no time should be spent in tentative measures. I refer to cases of fracture with puncture of an artery and hemorrhage from important arteries eroded by necrosed bone. It should be the rule for the surgeon at once to seek the injured artery and ligate it above and below the puncture, in fractures thus complicated; while, in cases of arterial hemorrhage caused by fragments of necrosed bone eroding the walls of a vessel, Markoe's precept to amputate at once in all cases where the lesion is located in a limb, cannot be improved upon. If amputation cannot be resorted to, the artery must be exposed, the dead bone

extracted, and the vessel ligated above and below the bleeding point.

Secondary hemorrhage needs attention in this connection. In accordance with the principles referred to as regulating the control of arterial hemorrhage, it would, at first glance, seem that they require the surgeon to enlarge the opening through which the blood is flowing, or to cut down upon the bleeding vessel should there be no opening in the skin, and tie or twist both ends of the vessel above and below the bleeding point. But this is not really so. The proper course to pursue is first to determine the end of the artery that is open; if the blood is dark, the hemorrhage is from the distal end; if scarlet, from the cardiac extremity. In the former case pressure will suffice to control the bleeding; in the latter in order to prove efficacious, pressure must be preceded by an operation. What is this operation? It is not enlarging the wound to tie the bleeding point, because the changes that have attended the casting off of the ligature have unfitted the end of the vessel to withstand pressure; the cord would cut its way through the softened tissues so soon as tightened. Again, the occlusion of the main channel at the ligated point, having by this time established new channels for the blood, we have in secondary hemorrhage two of the circumstances that favor the Hunterian operation—a diseased condition of the vessel at the site of the lesion, and a free collateral circulation. It is good surgery, therefore, to occlude the vessel at some point between the heart and the source of hemorrhage, but at some distance from the latter. By so doing a very striking result is obtained: the arterial pressure that before forced blood from the part, despite rest, position, local pressure, or general compression, is now removed by this procedure, and, although the open central end of the vessel remains unsealed, still, as the only blood that reaches it must find its way into it through the collateral circulation, any hemorrhage from it will present the appearance and have the characters of venous blood. In other words, while secondary hemorrhage from the distal end of an artery, the blood practically being venous, is controllable by pressure, it needs the Hunterian operation to effect the same change in the arterial blood flowing from the open central extremity. After this operation, however, the same measures that ordinarily control venous hemorrhage now suffice for the latter condition as well as the former.

In conclusion, I would summarize the matter in the following propositions:

1. Bleeding from an accessible artery should be checked by twisting or tying both ends of the vessel.

2. Moderate hemorrhage from one not readily reached, should be controlled by rest, position, local pressure, compression, etc.

3. Severe hemorrhage from an artery not controllable by pressure, etc., requires that the vessel be sought in the wound and both ends tied or twisted.

(*a*) An important exception is to be noted in some cases of wounds of the hands or feet: the danger of damaging important structures may lead the surgeon to tie or twist the brachial or femoral rather than seek the wounded branches of the palmar or plantar arches.

4. In fractures, complicated by wound or rupture of a large artery, the surgeon should at once cut into the swelling, turn out the clots, twist or ligate the central and peripheral ends of the arterial trunk.

5. In pulsating tumors, following wounds or injuries of arteries, should rest, position, local pressure or general compression fail to check their growth or diminish their size, an operation should be performed, the tumor opened, clots removed and the vessel tied or twisted above and below the lesion.

6. When a wound or injury of an artery has led to extravasation, no operation should be performed, so long as rest, position, pressure or compression can restrain further hemorrhage. (*a*) An exception to this rule is to be noted in cases where the amount of blood in the tissues is so great as to threaten their integrity by gangrene, or where, after checking further increase, the above measures fail to cause a diminution in the size of the tumor, despite the length of time they have been employed.

7. If the extravasation caused by arterial wound or injury cannot be held in check and further hemorrhage prevented by position, rest, local pressure or general compression, the tumor should at once be cut open, the clots removed, and the vessel tied or twisted above and below the point of injury.

8. In secondary hemorrhage, if the blood be dark, the bleeding is due to the patency of the distal end of the tied or twisted artery and can be controlled by position and compression. If the blood be red in color, it is arterial in character and comes from the central end of the vessel: here, owing to the condition of the vessel at the bleeding point the Hunterian operation is indicated, and after the artery is tied in a healthy part high up, the position and compression before only palliative, now suffice to effect a cure.